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RESEARCH ARTICLE

INTEGRATED NUTRIENT MANAGEMENT ON SUMMER MOONG BEAN (*VIGNA RADIATA* L.)

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Abstract: The main background of the study is objectives to study integrated effect of fertilizers, manures on growth,yield and quality of mungbean, to investigate the effect of bio-fertilizers on growth, yield andquality of mungbean, to assess the interactive effect of different treatments, if any and to evaluate the economics of different treatments.The present experiment was laid out inthe Research Farm, Department of Agronomy Agriculture, Indore, during 2021 and 2022.. The land topography of the experimental site wasalmost uniform with an adequate surface drainage.The conjunctive use of F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) and seed treatment with Rhizobium or PSB were determined to be the most successful treatments, according to thefindings of a one-year trial

Keywords: Fertilizers, Mungbeans, Economics, Nutrient

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek) is one ofthe main vegetable harvests in Asia. It is broadly filled in tropical and sub-tropical areasas a monoculture and as a part in trimming frameworks. Mungbean seeds are wealthy in fundamental amino acids and protein, and are effectively processed. In grain based district, mungbean supplies asignificant part of protein for destitute individuals, basically in the types of dry seed and bean sprout.Bruchid insects or seed weevils (Coleoptera:Bruchidae), especially azuki bean weevils(*Callosobruchus chinensis* L.) and cowpea weevils(C. maculatus F.) are the most damaging vermin ofmungbean during capacity (Talekar 1988). Thebruchids assault mungbean both prior and then afterwardcollect. Harm in the field is generally insignificant, but when the invaded seeds are put awaythe grown-ups arise and lay eggs on the adjoiningseeds. This subsequent invasion can cause absoluteharm of the seed parcel inside 3-4 months (Bantoalso, Sanchez 1972). Invasion of bruchids onmungbean seeds brings about weight reduction, lowgermination and change of nourishment in seedswhich are not good for human utilization, noragrarian and business utilizes (Talekar 1988).Bruchids can be constrained by synthetic substances, yet entirely asafe cultivar is more best because of no gambleon wellbeing and climate, and less expense ofinsect sprays. Hence, a significant objective in mungbeanrearing activities is to foster cultivars safeto bruchids (Srinives 1996).

A well spring of opposition against bruchids wasdistinguished in wild mungbean (*V. radiata var.sublobata* (Roxb.) Verdc.) promotion TC1966(Fujii and Miyazaki 1987) and has been broadlyutilized in mungbean reproducing programs. TC1966shows total protection from both C. chinensis furthe rmore, C. maculatus. The opposition is administered by a solitary predominant quality (Kitamura *et al*., 1988).Various bruchid safe lines were grown effectively involving TC1966 as the wellspring of opposition (Tomooka *et al*., 1992; Watanasit and Pichitporn 1996). Notwithstanding, a significant requirement inutilizing a wild mungbean in cultivar improvement isthe linkage drag of unfortunate characteristics like casedehiscent (Watanasit and Pichitporn 1996). Morecritically, seeds of wild vegetables, for example, that ofTC1966 are not allegedly consumed by human.This would require a thorough examinationon how safe it is for human utilization. Miuraet al. (1996) directed a taking care of test by utilizingBC14F4 seed of the cultivar 'Osaka Ryokutou'with TC1966 as the contributor of the quality givingthe opposition and found that glutamic-oxalacetictransaminase action was higher, while all outcholesterol focus was lower in femalemice took care of with the safe line contrasted and thecontrol mice. Consequently, more reasonable safesources would be required, ideally from developed assortments.

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Evaluating for protection from C. chinensis frommore than 1,000 AVRDC mungbean increases uncoveredthat V2709 and V2802 were impervious to thebruchids (Talekar and Lin 1981, 1992). No safepromotion was distinguished in the screening of 426 and330 mungbean landraces against the two bruchidspecies (Tomooka *et al*., 2000). In an extrascreening of 600 promotions of AVRDC's mungbean assortment in 2004, just V2709BG andV2802BG were affirmed to finish safefor C. chinensis and C. maculatus, albeit other increases showing critical obstruction was notfound (Somta et al., unpublished information). Subsequently, the developed mungbean V2709BG and V2802BG are considered as potential safe quality contributors.Be that as it may, these two increases have been dismissed by most mungbean reproducers and entomologists. However, their hereditary of the obstruction has notbeen accounted for up until this point.The current review is targeting distinguishing themethod of legacy of seed protection from C.chinensis and C. maculatus in promotionsV2709BG and V2802BG to help reproducing forbruchid obstruction in mungbean.

MATERIALS AND METHODS

The present experiment was laid out in the field of the Research Farm, Department of Agronomy Agriculture, Indore, during 2021 and 2022. The land topography of the experimental site was almost uniform with an adequate surface drainage. The internal drainage of the experimental site is good.

Geographical Situation

Indore is situated in Malwa Plateau in western part of Madhya Pradesh on latitude of 22^{o} 43” N and longitude of 75^{o} 66” E with an altitude of 555.5 meters above mean sea level.

Climate

Indore region comes under sub-tropical, semi-arid region, having a temperature range from 29^{o}C – 41^{o}C as maximum and 7^{o}C - 23^{o}C as minimum in summer and winter season, respectively. It is hottest during March to May while coolest in December and January. Relative humidity generally fluctuates between 30- 85%. In this area, most of the rainfall is received during mid June to early October while winter rains are occasional and uncertain. The annual rainfall is 954 mm. The south – west monsoon is responsible for the major precipitation.

The experiment was laid out in a randomized block design with Nine treatments and four replication viz. T1 (Control), T2 (RDF (20 kg N + 40 kg P2O5/ha), T3 (RDF + Rhizobium PSB), T4 (Compost (10 Kg/Ha), T5 (Compost (Rh+ PSB)), T6 (RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB) ,T7 (RDF (50%) + Compost (5 t/ha) + (Rh+ PSB), T8 (RDF (25%) + Compost (5 t/ha) + (Rh+ PSB) and T9 (RDF (75%) + Compost (5 t/ha) + (Rh+ PSB),(Nitrogen, phosphorus and Potassium were applied as per treatment, half dose of nitrogen, full dose of phosphorus and potassium were applied at time of sowing and rest dose of nitrogen in two equal split one at 45 and 2nd at 60 days after sowing. FYM and vermicompost were applied before 15 days of sowing. Seed treatment was done with PSB + Rhizobium (bio-fertilizer).

The layout of the experiment is given below. The treatment details are as follows:

Treatments combination:

Treatments

Sr. No.	**Fertility levels**	**Symbol**
(i)	Control	T1
(ii) *	RDF (20 kg N + 40 kg P2O5/ha)	T2
(iii)	RDF + Rhizobium + PSB	T3
(iv)	Compost (10 Kg/Ha)	T4
(v)	Compost (Rh + PSB)	T5
(vi)	RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	T6
(vii)	RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	T7
(viii)	RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	T8
(ix)	RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	T9

(B) Biofertilizers

i) Rhizobium	B1
ii) PSB	B2
(C) Absolute control	**Co**

***Recommended dose of fertilizer (N&P).**

Doses of organic manures were decided on equivalent N basis.

METHODOLOGY

(i) Design : Randomized Complete Block Design (RCBD)
(ii) Gross Plot size : 15 m × 55 m
(iii) Net Plat Size : 12 m * 45 m
(iv) Variety : Samrat(PDM- 139)
(v) Season : Zaid/ Summer
(vi) Number of Treatment :
Number of replications : 4
Total number of plots : 9 × 4 = 36
Row Spacing : 30 cm
Seed Rate : 20 Kg/ Ha

Observations to be recorded :
In order to evaluate the effect of different treatments on growth, yield and quality of crop, necessary periodical observations were recorded, particulars of which are given as under :

Growth attributes

Plant stand
Plant stand per metre row length was counted at 20 DAS, 50DAS and at harvest from five randomly selected spots in each plot and the average was worked out.

Plant height
Five plants were selected randomly from each plot, tagged permanently and used for measurement of plant height. Height of the main shoot i.e., from the ground surface to base of fully expanded leaf was measured by metre scale in centimetres. Average plant height at each growth stage (25, 50 DAS and at harvest) was worked out.

Dry matter accumulation per metre row length
Plants from one metre row length were uprooted from sample rows of each plot at 25, 50 DAS and at harvest. After removal of the root portion, the samples were first air dried for some days and finally dried in an electric oven at 700C till a constant weight was achieved. The weight was recorded and expressed as average dry matter in g per metre row length.

Number of branches per plant
Five plants randomly selected and tagged permanently in each plot for height measurement were used to record the number of branches per plant at 50 DAS and at harvest and their average was worked out.

Chlorophyll content
The chlorophyll content at 40 DAS was estimated by taking 50 mg fresh leaf material. Samples were homogenized in 80% acetone, centrifuged for 10 minutes at 2000 rpm and made final volume to 10 ml. Absorbance of clear supernatant solution was measured by Spectronic-20 at 652 nm and presented in terms of mg/g fresh weight of leaves.

Total chlorophyll (mg/g)

$$= \frac{A652 \times 29 \times \text{Total volume (ml)}}{\alpha \times 1000 \times \text{weight of sample (g)}}$$

where, α is length of path = 1 cm

Total and effective number of nodules per plant
The total and effective number of nodules per plant was counted at 40 DAS. Five plants were selected randomly in sample rows of each plot and uprooted carefully. The soil mass embodying the roots of the plants was washed off with water and total as well as effective root nodules were counted to record the average number of nodules per plant.

Fresh and dry weight of nodules per plant (mg)
The total root nodules so obtained from the five plants from each plot were weighed and then subjected to oven dry at 700C till a constant weight was obtained and then average was worked out.

Yield attributes and yield

Number of pods per plant
The randomly selected plants used for recording the height and branches were used for counting the total number of pods at harvest and their average was worked out to record the number of pods per plant.

Number of seeds per pod
Number of seeds per pod was recorded at harvest by counting the number of seeds of ten randomly selected pods from five tagged plants and the average was taken.

Test weight
One thousand seeds were counted from the sample drawn randomly from the finally winnowed and cleaned produce of each plot and their weight was recorded as test weight.

Yield

Biological yield
After complete sun drying, picked pods and harvested bundles of each net plot (3.0 m x 1.8 m) were weighed for biological yield and converted in terms of kg/ha.

Seed yield
The total biomass of each plot was threshed and cleaned. The seeds so obtained were weighed and converted into kg/ha.

Straw yield
Straw yield was calculated by subtracting the seed yield from biological yield (kg/ha).

Harvest index
Harvest index was computed by using the formula outlined.

Harvest index (%)

$$= \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

Quality parameters and nutrient uptake

Nutrient concentration

The representative samples of seed and straw drawn at the time of threshing were first oven dried and then ground by an electric grinder (Wiley mill) were utilized for N, P and K estimation.

(i) Nitrogen concentration in seed.

Nitrogen was estimated by digesting the seed and straw samples with sulphuric acid using hydrogen peroxide to remove black colour. Estimation of nitrogen was done by colorimetric method using Nessler‟s reagent to develop colour. The results so obtained were expressed as percent nitrogen concentration.

(ii) Phosphorus concentration in seed.

Phosphorus concentration in seed and straw was determined by Vanadomolybdo phosphoric acid yellow colour method. Digestion of samples was done by tri-acid mixture (Jackson, 1973).

(iii) Potassium concentration in seed.

Potassium concentration in the samples used earlier was determined by digesting them in tri-acid mixture of HNO_3 : H_2SO_4 : $HClO_4$ and was estimated by flame photometric method.

Nutrient uptake

The uptake of N, P and K at harvest in seed and straw was estimated by using following formula

Nutrient uptake (kg/ha) =

$$\frac{\text{Nutrient conc. in seed (\%) x Seed yield (kg/ha) + Nutrient conc. in straw (\%) x Straw yield (kg/ha)}}{100}$$

Protein content in seed

The percent crude protein content in seed was calculated by multiplying per cent nitrogen of seed with a factor 6.25

Economics of treatments

The produce obtained under each treatment was multiplied with the prevailing market price of seed and straw to get the gross returns. The cost of cultivation for each treatment was subtracted from the gross returns and net returns were worked out accordingly.

Statistical analysis

The experimental data recorded for growth, yield and other characters were statistically analyzed by Fisher's analysis of variance technique (Fisher, 1950). Appropriate standard error for each of the factor was worked out. Significance of differences among treatment effects was tested by "F" test. Critical difference (CD) was worked out wherever the difference was found to be significant at 5 or 1 per cent level of significance. The analyses of variance of different components for all parameters are given

RESULTS

Results obtained in the present investigation entitled “Integrated Nutrient Management in Mungbean [Vigna radiata (L.)]” conducted during kharif season of 2021- 2022 at Agronomy farm,Indore are presented in this chapter. During the course of investigation, the observations were recorded on various aspects i.e. Growth characters, Yield attributes and yield, Yield and Quality parameters and nutrient uptake and are presented and discussed in this chapter under appropriate headings and sub headings.

Growth characters

Plant stand

A from the data (Table 4.1 and fig. 1) it was studied that the effect of changing fertility levels and bio-fertilizer treatments on plant population recorded at 25 DAS and at harvest was not found to be significant. Therefore, the plant stand was almost uniform in all the treated plots.

Table 1. Effect of fertility levels and bio-fertilizers on initial and final plant stand

Treatment	Plant stand per meter row length	
	25 DAS	At harvest
Fertility levels		
F1 - RDF (20 kg N + 40 kg P_2O_5/ha)	**11.3**	**10.3**
F2 - RDF + Rhizobium + PSB	**10.8**	**10.0**
F3 - Compost (10 Kg/Ha)	**11.8**	**10.2**
F4 - Compost (Rh + PSB)	**11.0**	**10.2**
F5 - RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	**10.8**	**10.3**
F6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	**11.2**	**10.2**
F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	**11.5**	**10.5**
F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	**12.9**	**15.6**
SEm+	**0.3**	**0.2**

CD. (P=0.05)	**NS**	**NS**
Bio-fertilizers		
B1 – Rhizobium	**11.3**	**10.2**
B2 – PSB	**11.1**	**10.3**
SEm+	**0.2**	**0.2**
CD. (P=0.05)	**NS**	**NS**

Plant height
A data presenting in (Table 3.2 and fig. 2) indicated that the effect of different fertility levels and bio-fertilizer treatments did not bring significant effect on plant height over control at 25 DAS. However, the plant height was significantly changes due to above treatments at later stages i.e. at 50 DAS and at harvest.

Fertility levels: The data in respect of plant height on various fertility and bio-fertilizer treatments presented in table 4.2. The data mention in (table 3.2) for present investigation that revealed the plant height of crop was gradually increased from 25 DAS to harvesting. At 25 DAS, varying fertility levels were treatment F8 notice a maximum (21.2) plant height of the plants. However, their use had a considerable impact on plant height at later periods, such as 50 DAS and harvest, where the treatment, F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) recorded the maximum (41.2) plant height which was significantly higher by rest of the treatments at 50 DAS and significantly minimum (28.3) plant height was observed in treatment F2 (RDF + Rhizobium + PSB). At harvest the maximum height was noticed in the treatment F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) which was at par with treatment F7, F6, F5and treatmentF4respectively.

Bio-fertilizers: At every stage of growth, seed inoculation with PSB (B2) was considerably superior than seed inoculation with Rhizobium (B1) in terms of plant height. However, both interventions outperformed the control (Table 1).

Table 2. Effect of fertility levels and bio-fertilizers on plant height (cm) at different stages

Treatment	**Plant height**		
	25 DAS	**50 DAS**	**At harvest**
Fertility levels			
F1 - RDF (20 kg N + 40 kg P2O5/ha)	**12.6**	**31.6**	**41.1**
F2 - RDF + Rhizobium + PSB	**11.8**	**28.3**	**32.9**
F3 - Compost (10 Kg/Ha)	**14.6**	**31.6**	**44.3**
F4 - Compost (Rh + PSB)	**12.4**	**30.8**	**45.7**
F5 - RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	**16.2**	**35.6**	**48.4**
F6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	**18.7**	**31.1**	**46.2**
F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	**16.9**	**35.2**	**47.4**
F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	**21.2**	**41.2**	**50.2**
SEm+	**0.4**	**1.0**	**1.0**
CD. (P=0.05)	**NS**	**3.0**	**3.0**
Bio-fertilizers			
B1 – Rhizobium	**8.3**	**32.7**	**47.3**
B2 - PSB	**8.1**	**31.3**	**45.8**
SEm+	**0.1**	**0.6**	**0.6**
CD. (P=0.05)	**NS**	**NS**	**NS**

Number of branches per plant
The data in respect of Effect of fertility levels and bio-fertilizers on number of branches per plant at different stages ware presented in table (Table 3.3 and Fig.) showed that the effect of varying fertility levels and bio-fertilizer treatments significantly increased the number of branches per plant by at 50 DAS and at harvest, respectively as compared to control.

Fertility levels :A data presented in table (Table 3.3 and Fig. 3) showed that the treatment, F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)was recorded the maximum number of branches (36.58) per plant which was significantly higherby rest of the treatments at 50 DAS and significantly minimum (15.26) treatment F2 - RDF + Rhizobium + PSB is recorded. At harvest the maximum branches (46.22) per plant at different stageswas recorded in the treatment F8- RDF (75%) + Compost (5 t/ha) + (Rh+ PSB).minimum (18.59) treatment F2 - RDF + Rhizobium + PSB is recorded.

Bio-fertilizers: The data (Table 2 and Figure 2) showed that the number of branches per plant was increased by applying Rhizobium (B1) and PSB (B2) at both stages. i.e.50 DAS and at harvest are not significantly different from each other.

Table 3. Effect of fertility levels and bio-fertilizers on number of branches per plant at different stages.

Treatments	50 DAS	At harvest
Fertility levels		
F1 - RDF (20 kg N + 40 kg P2O5/ha)	23.50	29.14
F2 - RDF + Rhizobium + PSB	15.26	18.59
F3 - Compost (10 Kg/Ha)	15.77	22.13
F4 - Compost (Rh + PSB)	17.78	21.41
F5 - RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	22.50	30.17
F6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	23.50	31.76
F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	27.31	34.27
F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	36.58	46.22
SEm+	0.2	0.2
CD. (P=0.05)	0.6	0.6
Bio-fertilizers		
B1 – Rhizobium	18.10	26.30
B2 – PSB	14.50	21.10
SEm+	0.11	0.13
CD. (P=0.05)	NS	NS

Chlorophyll content

The data in respect of Effect of fertility levels and bio-fertilizers on total chlorophyll content at 40 DAS are presented in (Table 3 and fig 3) chlorophyll content at 40 DAS exhibited significant increase over control due to application of different fertility levels and bio-fertilizer treatments.

Fertility levels : The data presented in Table 4.5 indicated that the application of different fertility treatments to mungbean significantly increased the total chlorophyll content in crop leaves wherein, the treatment F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)is significantly maximum (3.92) chlorophyll content (mg/g) at 40 DAS while significantly minimum (2.23) Total chlorophyll content (mg/g) was recorded in treatmentF2 - RDF + Rhizobium + PSB is recorded.

Bio-fertilizers: The data presented in the same table further revealed that the application of biofertilizers could not bring about a significant change between them in terms of chlorophyll content in leaves. However, their application significantly improved the chlorophyll content compared with the control.

Table 4. Effect of fertility levels and bio-fertilizers on total chlorophyll content at 40 DAS

Treatments	Total chlorophyll content (mg/g)
Fertility levels	
F1 - RDF (20 kg N + 40 kg P2O5/ha)	2.59
F2 - RDF + Rhizobium + PSB	2.23
F3 - Compost (10 Kg/Ha)	3.44
F4 - Compost (Rh + PSB)	3.36
F5 - RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	3.70
F6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	3.20
F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	3.80

F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	3.92
SEm+	0.21
CD. (P=0.05)	0.37
Bio-fertilizers	
B1 – Rhizobium	2.98
B2 – PSB	2.88
SEm+	0.11
CD. (P=0.05)	NS

Total and effective number of nodules per plant
A critical investigation of data (Table 3.5 and fig 4) showed that application of different fertility levels and bio-fertilizers significantly increased the total number of root nodules per plant.

Fertility levels : The data presented in Table (Table 3.5) showed that treatment F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)recorded the significant maximum total number (48.71) of root nodules per plant and effective nodule per plant.(32.21) Whereas, Effect of fertility levels and bio-fertilizers on significantly minimum total nodules (24.72)and effective nodule per plant (17.97)in treatment F2 - RDF + Rhizobium + PSB respectively.

Bio-fertilizers: The data presented in Table (Table 4.6) studied that application of bio-fertilizers significantly enhanced the total number of nodules over control but both Rhizobium and PSB were at par in their effect on number of nodules.

Table 5. Effect of fertility levels and bio-fertilizers on number and weight of nodules per plant at 40 DAS

Treatments	**Total nodules**	**Effective nodules**	**Fresh weight (mg)**	**Dry weight (mg**
Fertility levels				
F1 - RDF (20 kg N + 40 kg P2O5/ha)	28.30	19.17	349.56	56.55
F2 - RDF + Rhizobium + PSB	24.72	17.97	254.14	49.67
F3 - Compost (10 Kg/Ha)	26.72	18.17	328.52	53.33
F4 - Compost (Rh + PSB)	26.94	17.56	248.65	51.28
F5 - RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	27.59	15.61	389.09	60.76
F6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	25.01	14.34	322.08	52.94
F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	32.78	20.22	412.61	61.23
F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	48.71	32.21	438.87	63.21
SEm+	0.85	0.85	14.39	3.34
CD. (P=0.05)	2.45	2.45	41.57	3.88
Bio-fertilizers				
B1 – Rhizobium	28.95	18.47	319.34	57.79
B2 – PSB	24.96	16.24	268.12	51.42
SEm+	0.45	0.45	7.69	0.72
CD. (P=0.05)	NS	NS	NS	NS

Fresh weight of root nodules per plant
It is investigating from data (Table 3.5 and fig 5) that different fertility levels and bio-fertilizer treatments significantly increased the fresh weight of root nodules per plant by 56.03 per cent as compared to control.

Fertility levels: It is studied from data (Table 3.5) that the significantly maximum (438.87) fresh weight of root nodules per plant in treatment, F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)which was recorded significantly superior than rest of all the treatments,. Whereas the fresh weight of root nodules recorded minimum (248.65) in treatment F4 - Compost (Rh + PSB), respectively.

Bio-fertilizers: Data presented in (Table 4.6) showed that difference in the fresh weight of nodules between Rhizobium (B1) and PSB (B2) inoculation was not significant. However, both preparations were superior to the control in terms of fresh weight of root nodules per plant.

Dry weight of root nodules per plant

The data (Table 5 and fig 5) clearly showed that the application of different fertility levels and the biofertilizer treatments significantly increased the root nodule dry weight per plant compared with the controls.

levels: Data (Table 4) showed that fertility levels had significant effect on dry weight of nodules per plant. The maximum value(63.21) of this parameter was notedintreatment F8-RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) which remaining treatment F7 And F5 at par with RDF (25%) + Compost (5 t/ha) + (Rh+ PSB) (F7) and RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)(F5), respectively.

Bio-fertilizers: Both inoculants Rhizobium and PSB had significant influence on dry weight of nodules over control presented in table (Table 4.6). However, these were not found to significantly from each other.

Yield attributes and yield

Number of pods per plant

It is conform from data (Table 3.6 and Fig. 6) that application of different fertility levels and bio-fertilizer treatments significantly increased number of pods per plant over control.

Fertility levels : The data representing in table (Table 3.6 and Fig. 6) showed that number of pods per plant noted was significantly maximum (35.84) in RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) *i.e.* treatment - F8At harvest, followed by treatmentF_6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB) (22.11) and treatment F_7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB) respectively. While the minimum (16.28) no of pod per plant is noted in treatment F_2 - RDF + Rhizobium + PSB.

Bio-fertilizers: Data (Table 3.6 and Fig. 6) further revealed that the maximum number of pods per plant was attained when the crop was inoculated with Rhizobium (B1). This treatment was also found at par with PSB (B2) but both the inoculants proved superior to control.

Number of seeds per pod

A critical investigation of data (Table 3.6 and Fig. 6) showed that application of verious fertility levels and bio-fertilizers significantly increased the total number of seeds per pod over control.

Fertility levels : The data in respect ofnumber of seed per pod presented in (Table 4.7 and Fig. 4.3) show that various fertility levels had significant effect on number of seeds per pod of mungbean. The significant maximum(10.68) number of seeds per pod was recorded in treatment F8 - i.e. RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)which was superior from rest of all. Significantly minimum (7.78) number of seed per pod was recorded in treatment F2 - RDF + Rhizobium + PSB

Bio-fertilizers : Data presented in (Table 3.6 and Fig. 6) further revealed that the number of seeds per pod over control was improved due to seed inoculation with Rhizobium (B1) and PSB (B2), the both remained at par with each other.

Test weight

Data showed non-significant variations in test weight (g) due to various fertility levels and bio-fertilizer application (Table 5).

Table 6. Effect of fertility levels and bio-fertilizers on yield attributes

Treatments	Pods/ plant	Seeds/ pod	Test weight (g)
Fertility levels			
F1 - RDF (20 kg N + 40 kg P2O5/ha)	19.27	9.39	32.59
F2 - RDF + Rhizobium + PSB	16.28	7.78	31.58
F3 - Compost (10 Kg/Ha)	19.11	9.17	32.51
F4 - Compost (Rh + PSB)	18.46	7.82	32.26
F5 - RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	19.00	9.26	34.43
F6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	22.11	9.11	32.46
F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	21.61	7.53	32.31
F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	35.84	10.68	37.10
SEm+	0.62	0.28	1.00
CD. (P=0.05)	1.78	0.81	0.74
Bio-fertilizers			

B1 – Rhizobium	18.36	7.29	29.00
B2 – PSB	16.93	8.16	30.46
SEm+	0.33	0.15	0.53
CD. (P=0.05)	NS	NS	NS

Yield

Biological yield

Biological yield

A critical observation of data (Table 3.7 and Fig 7) showed that application of different fertility levels and bio-fertilizers significantly increased the biological yield as compared to control.

Fertility levels: A data presented im (Table 3.7 and Fig. 7) indicated that similar to seed and straw yield there was significant increase in biological yield due to various fertility treatments. The treatment, F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) recorded the significant maximum biological yield (3941 kg/ha) which was significantly superiors rest of all the treatments. Whereas the minimum (3285) biological yield is recorded in treatment F2 - RDF + Rhizobium + PSB.

Bio-fertilizers: Both the factor was found to enhance biological yield significantly over control (Table 4.8 and Fig. 4.4). However, application of Rhizobium (B1) proved to be as good as PSB (B2). Value of differentiation in biological yield due to Rhizobium and PSB as compared to absolute control.

Seed yield

A data presented in table (Table 3.7 and Fig. 7) indicated that application of fertility levels and bio-fertilizers significantly increased the seed yield by compared with control.

Fertility levels : From the data (Table 4.8 and Figure 4.4), it was concluded that mung bean seed yield was significantly increased by applying different levels of fertility. The maximum (1531) seed yield was recorded F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB). While the minimum (1007) seed yield was obtained from treatment F2 - RDF + Rhizobium + PSB.

Bio-fertilizers: Data presented in table 4.8 and fig. 4.4 further revealed that seed yield was significantly affected by bio-fertilizer treatments compared with control. Inoculation of mungbean seed with Rhizobium noted the higher seed yield (1270 kg/ha) as compared to that of PSB (1156 kg/ha). However, both were at par in this regard. Seed yield obtained under absolute control was 748 kg/ha.

Straw yield

Data presented in (Table 3.7 and Fig. 7) showed that application of different fertility levels and bio-fertilizers significantly increased the straw yield as comparison to control.

Fertility levels: A critical investigation of data (Table 3.7 and Fig. 7) resulting to the straw yield revealed that the maximum (2769 kg/ha) straw yield was recorded with F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) which significantly superior over rest of the all treatments. Whereas the minimum (2278) straw yield was recorded in treatment F2 - RDF + Rhizobium + PSB.

Bio-fertilizers: Further study showed (Table 3.7 and Fig. 7) that bio-fertilizers causing significant increase in straw yield of mungbean over control also followed the same trend as the seed yield wherein the straw yield obtained under Rhizobium and PSB was higher compared to absolute control.

Harvest index

A review of the data revealed that different fertility levels and bio-fertilizer treatments had no discernible impact on harvest index (Table 6).

Table 7. Effect of fertility levels and bio-fertilizers on seed, straw and biological yields and harvest index.

Treatments		Yield (kg/ha)		
	Seed	Straw	Biological	Harvest index (%)
Fertility levels				
F1 - RDF (20 kg N + 40 kg P2O5/ha)	1184	2479	3663	32.31
F2 - RDF + Rhizobium + PSB	1007	2278	3285	30.67
F3 - Compost (10 Kg/Ha)	1169	2467	3636	32.13
F4 - Compost (Rh + PSB)	1097	2296	3393	32.33
F5 - RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	1226	2486	3712	33.05
F6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	1139	2450	3588	31.73
F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	1315	2633	3894	33.91

F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	1531	2769	3941	34.27
SEm+	44	52	100	1.27
CD. (P=0.05)	126	151	288	NS
Bio-fertilizers				
B1 – Rhizobium	1270	2365	3535	32.14
B2 – PSB	1156	2318	3352	32.64
SEm+	22	26	52	0.64
CD. (P=0.05)	NS	NS	NS	NS

Quality parameters and nutrient uptake

Nutrient concentration and their uptake

Nitrogen concentration in seed

The data presented in table (Table 6) is indicated that the nitrogen percent in seed significantly increased over control due to treatments. The increase in nitrogen content in seed due to application of fertility levels and bio-fertilizers over control.

Fertility levels: the data mention in (Table 6) showed that various fertility levels significantly enhanced the nitrogen content in seed. The treatment, F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) was noted the significantly maximum (3.876) nitrogen content in seed which was significantly higher as compared to rest of the treatments. Whereas the treatment, F2- RDF + Rhizobium + PSB recorded minimum (3.084) N content in seed, respectively.

Bio-fertilizers: A further observation of data (Table 6) indicated that application of bio-fertilizers significantly affected the nitrogen percentage in seed wherein the treatments, Rhizobium (B1) and PSB (B2) brought an increase of over control, respectively. However, there was non-significant difference between both the treatments.

Nitrogen concentration in straw

The data presented in (Table 6) showed that application of different fertility levels and bio-fertilizers significantly increased N percentage in seed when compared with control.

Fertility levels: A studied to data presented in (Table 3.8) show that N content in straw also followed the same trend as that of seed. The treatment, F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) recorded the significantly maximum (2.106) number of N content in straw which being superior from rest of all treatment. Whereas the treatmentF2 - RDF + Rhizobium + PSB recorded minimum (0.970) percent of N in strow, respectively.

Bio-fertilizers: It is conformed from data mention in (Table 7) that application of Rhizobium (B1) and PSB (B2) significantly increased the nitrogen percent in straw over control but both remained at par with each other. The increase in nitrogen content due to Rhizobium (B1) and PSB (B2) over control was to the extent of 1.120 and 1.171 per cent, respectively.

Total nitrogen uptake

It is conform from data mention in (Table 3.8 and Fig. 8) that application of different fertility levels and bio-fertilizers significantly increased the total nitrogen content over the control.

Fertility levels: A review of the data (Table 3.8 and Fig. 8) showed that total N uptake influenced significantly due to different fertility levels. The maximum (88.21) nitrogen uptake noted under the treatment, F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) significantly more than rest of the all the treatments. these treatment at par with treatment F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB) the total N uptake in this treatment was observed is 86.29. the minimum (52.22) nitrogen uptake was observed in treatment F2 - RDF + Rhizobium + PSB.

Bio-fertilizers: Data presented in (Table 3.8 and Fig. 8) indicated that both the bio-fertilizer treatments significantly enhanced the uptake of nitrogen compared with control, although, difference between the two could not significance.

Protein content in seed

The application of fertility levels and bio-fertilizers considerably enhanced the protein content in seed when compared to control, according to data analysis of table (Table 7).

Table 8. Effect of fertility levels and bio-fertilizers on nitrogen concentration in seed and straw, nitrogen uptake and protein content in seed.

Treatments	N concentration		Total N uptake (kg/ha)	Protein content in seed (%)
	Seed	Straw		
Fertility levels				
F1 - RDF (20 kg N + 40 kg P2O5/ha)	3.369	1.146	68.02	22.03

F2 - RDF + Rhizobium + PSB	3.084	0.970	52.22	20.21
F3 - Compost (10 Kg/Ha)	3.301	1.164	65.84	21.64
F4 - Compost (Rh + PSB)	3.165	1.059	58.92	19.73
F5 - RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	3.512	1.328	75.93	21.90
F6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	3.568	1.071	62.82	20.08
F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	3.679	1.390	86.29	20.99
F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	3.876	2.106	88.21	23.10
SEm+	0.079	0.032	4.12	0.69
CD. (P=0.05)	0.228	0.086	11.80	1.97
Bio-fertilizers				
B1 – Rhizobium	3.347	1.120	67.79	20.08
B2 – PSB	3.220	1.171	66.28	21.71
SEm+	0.040	0.016	2.18	0.35
CD. (P=0.05)	NS	NS	NS	NS

Phosphorus concentration in seed

A critical analysis of data mention in (Table 3.9) indicated that treatment of different fertility levels and bio-fertilizers considerably enhanced the phosphorus concentration in seed as compared with control.

Phosphorus concentration in straw

The Data represented in table (Table 7) indicated that treatment of various levels of fertility and bio-fertilizers significantly increased the phosphorus concentration in straw as comparison to control.

Total phosphorus uptake

The findings (Table 7 and Fig. 9) demonstrate that applying different fertility levels and biofertilizers above control resulted in a considerable increase in total phosphorus absorption.

Table 9. Effect of fertility levels and bio-fertilizers on phosphorus concentration in seed and straw and phosphorus uptake

Treatments	P concentration (%)		Total P uptake (kg/ha)
	Seed	Straw	
Fertility levels			
F1 - RDF (20 kg N + 40 kg P2O5/ha)	0.288	0.168	7.20
F2 - RDF + Rhizobium + PSB	0.215	0.140	5.35
F3 - Compost (10 Kg/Ha)	0.280	0.158	7.45
F4 - Compost (Rh + PSB)	0.250	0.148	6.35
F5 - RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	0.325	0.160	6.68
F6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	0.240	0.177	8.72
F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	0.334	0.201	8.94
F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	0.339	0.208	9.21
SEm+	0.013	0.013	0.42
CD. (P=0.05)	0.033	0.035	1.21
Bio-fertilizers			
B1 – Rhizobium	0.274	0.165	7.22
B2 – PSB	0.292	0.181	7.70
SEm+	0.007	0.007	0.22
CD. (P=0.05)	NS	NS	NS

Potassium concentration in seed

The treatment of different fertility levels and bio-fertilizers considerably enhanced the potassium concentration in seed as compared to control, according to data presented in (Table 3.10).

Potassium concentration in straw

The findings (Table 8) make it clear that varied fertility levels and biofertilizers considerably raised the K content in straw compared to the control.

Total potassium uptake

The findings (Table 8 and Fig. 10) clearly show that the treatment of varied fertility and biofertilizer levels over control resulted in a considerable increase in total potassium absorption.

Table 10. Effect of fertility levels and bio-fertilizers on potassium concentration in seed and straw and potassium uptake

Treatments	K concentration (%)		Total K uptake (kg/ha)
	Seed	**Straw**	
Fertility levels			
F1 - RDF (20 kg N + 40 kg P2O5/ha)	1.183	1.741	54.32
F2 - RDF + Rhizobium + PSB	1.152	1.480	44.48
F3 - Compost (10 Kg/Ha)	1.178	1.720	55.38
F4 - Compost (Rh + PSB)	1.160	1.625	51.21
F5 - RDF (50%) + Compost (2.5 t/ha) + (Rh+ PSB)	1.285	1.721	60.68
F6 - RDF (50%) + Compost (5 t/ha) + (Rh+ PSB)	1.332	1.778	62.72
F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB)	1.398	1.829	66.21
F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)	1.421	2.021	72.94
SEm+	0.082	0.096	2.82
CD. (P=0.05)	0.213	0.278	7.21
Bio-fertilizers			
B1 – Rhizobium	1.276	1.795	58.22
B2 – PSB	1.270	0.681	52.70
SEm+	0.044	0.048	01.58
CD. (P=0.05)	NS	NS	NS

DISCUSSION

In the present experiment entitled "Integrated Nutrient Management in Mungbean [Vigna radiata (L.)] " significant difference was recorded in the criteria used for evaluating the treatments. In this chapter, an attempt is made to describe significant events or events that assume certain patterns in relation to the various parameters studied in order to establish causality in the light of the available evidence and literature.

Effect of fertility levels

Growth characters

Results showed that different fertility levels was a considerable effect on Plant stand per meter row length, plant height, number of branches per plant, Chlorophyll content and number and weight of nodules per plant (Table 3.1, 3.2, 3.3, 3.4.4 and 3.5). The maximum values of these parameters were observed under treatment F8 - RDF (75%) + Compost (5 t/ha) + (Rh+ PSB)followed by treatment F7 - RDF (25%) + Compost (5 t/ha) + (Rh+ PSB). The results of the study show that a suitable concatenation of organic and inorganic fertilizers maintains long term soil fertility and sustain high level of productivity (Pillai et al., 1985). The enhanced availability of nitrogen and phosphorus to the plant, first through fertilisers and subsequently through manures in the cropping season, may be the cause of the higher growth and development shown in the aforementioned treatments. In comparison to other treatments, the application of RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) resulted in better growth in terms of plant height and the number of branches per plant. This may be due to the additional benefits of 75% RDF, Compost, Rhizobium, and

PSB in addition to providing all the necessary nutrients. By providing assimilates to the roots, compost, rhizobium, and PSB help the roots grow and proliferate, which improves nodule formation and nitrogen fixation. Additionally, it improves the soil'sCEC, water holding capacity, organic carbon content, and phosphate availability, which creates a better environment for growth and development in the rhizosphere.

Additionally, the early release of nutrients during the crop phase was boosted by the quick mineralization caused by the narrow C:N ratio (12;1). Such beneficial effects of Rhizobium and PSB with readily available source (inorganic fertilizer) and betteredaphic environment available to the crop might have improved all the growth attributes. However, one of the main processes used by bacteria associated with plants to promote plant development is the solubilization of inorganic phosphate. In order to do this, microorganisms in the soil release organic acids that solubilize phosphate complexes and transform them into ortho-phosphate, which plants can absorb and use. In a field experiment found that combined seed inoculation with PSB + Rhizobium significantly increased the plant height, branches per plant, dry matter, number and dry weight of nodules per plant in mungbean over control and inoculation with either PSB or Rhizobium. Organic manures are known to improve the biological and physical characteristics of soil, increasing the availability of nearly all plant nutrients. Plants need to grow and develop. Thus, a healthy diet in a favourable environment may have aided in the growth of new tissues and new shoot growth, which has eventually enhanced plant height, dry matter accumulation, and branch count per plant.

Yield attributes and yield

The number of pods per plant and the number of seeds per pod greatly increased as a result of the application of fertility levels (Table 7).

Nutrient content, uptake and quality

Nitrogen concentrations in seed and straw (Table 8) were considerably raised as a result of nitrogen application from various sources, which might be attributed to improved nitrogen availability to plants.

Effect of biofertilizers

Growth characters

The considerable increase in plant height, branches/plant and dries matteraccumulation per meter row at 50 DAS and at harvest was found owing to seed inoculation with Rhizobium or PSB above absolute control.

Yield attributes and yield

In comparison to the absolute control, seed treatment using Rhizobium and PSB considerably increased pods/plant, seeds/pod, as well as seed, straw, and biological yields.

Nutrient concentration, uptake and protein content

Rhizobium and PSB seed inoculation considerably increased N, P, and K concentration and absorption as well as nutrient content in seed compared to absolute control. Rhizobium inoculation resulted in considerably greater content and absorption than PSB and was determined to be superior to the absolute control (Tables 3.8 and 3.9).

CONCLUSION

The conjunctive use of F8 -RDF (75%) + Compost (5 t/ha) + (Rh+ PSB) and seed treatment with Rhizobium or PSB were determined to be the most successful treatments in both year, according to the findings of a two-year trial. Since these treatments significantly increased mungbean output and net returns when compared to the matching solo treatment either by compost or inorganic fertilizers and no inoculation.

To get a more conclusive and consistent conclusion, additional research is needed as current data are simply suggestive.

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